Science MATTERS! ... IN CONNECTICUT

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Filling Materials Data Gaps for Advanced Manufacturing

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Connecticut is home to an impressive manufacturing and innovation history. As technology, economic demand, and expertise have changed, so has the nature of manufacturing in our state. Connecticut is currently the top employer of aerospace-related jobs in the country (when normalized against state population), and this is quite different from the heavy manufacturing and metal products processing of 100 years ago. There are three key ways that the aerospace industry has continued to innovate and grow.

(1) **Innovation through materials knowledge. Materials Scientists and Engineers** study materials processing to control **materials properties**. Understanding the behavior, structures, and properties of the materials allows us to find novel ways to produce something that can survive higher temperatures, higher pressures, and more demanding applications.

(2) **Innovation through models and simulation.** Models are built to describe both the material and the process. Instead of making dozens of prototypes to perfect a manufacturing process, it is possible to run simulations using our models. If the models are accurate, the simulations can provide the information we need about the processing requirements. The models can even be used to create a **Digital Twin** of a part as it goes through manufacturing.

(3) **Precision in manufacturing**. We next need a manufacturing system that can actually produce the material component. The precise control of specific manufacturing parameters, like temperature and applied forces, is often essential for the production of advanced materials.

Here is the challenge: in order to predict the behavior of materials in a newly designed part, we need to know the behavior of the materials during processing. Our models MUST be accurate! Creation of accurate models can be extremely challenging as the properties of materials continuously change during processing. Measuring constantly changing properties requires highly specialized instruments and controlled materials testing. This is exactly what the Center for Materials Processing Data (CMPD) focuses on at the University of Connecticut. In the Innovation Partnership Building at UConn, researchers use **electron microscopes** and mechanical testing equipment to measure and characterize how materials change with different manufacturing parameters. Carefully collected data are fed into models that describe materials behaviors during manufacturing sequences. Four equally important aspects of accurate models of materials behavior include testing and measurement of materials (the UConn piece to the puzzle), creation of models and simulations (the center's collaborators at Worcester Polytechnic Institute assist with this), an ability to process and understand all of the data (University at Buffalo uses **materials informatics and machine learning** methods to do this), and a way to store and make the data available to industry partners (this is where materials professional society, ASM International, excels). UConn researchers work closely with industry partners to focus on key materials and manufacturing challenges to fill in the gaps in our knowledge of advanced materials manufacturing.

Meet the Scientist

I have always loved puzzles. It doesn't matter what kind (word puzzles, 3-dimensional puzzles, jigsaw); I love them all. This is probably why I became an engineer. An engineer is a person who has trained herself to think about puzzles with the goal of not just solving a problem, but also figuring out how to solve the problem faster, cheaper, and better.

SKILLS & KNOWLEDGE

There are several aspects to manufacturing (hands-on testing and measurement, operating advanced equipment, computer simulations and models, data analysis), and we need people who are excited by any or all of these. STEM education is essential here, and the individuals who will do well have in common a passion for figuring things out.

Words To Know

Materials Science and Engineering: The study of how materials are made and how they behave in different environments. Materials include metals, ceramics, polymers (plastics) and composite mixtures of these.

Materials properties: Can include aspects like strength, melting temperature, magnetic properties, optical properties and many others.

Digital Twins: A digital copy of a manufactured part, which allows prediction of how it will react to processing and what properties it will have once production is complete.

Electron microscopy: A method using a focused electron beam instead of visible light to view a material.

Materials informatics and machine learning: Searching for patterns of materials behaviors through many different datasets and using computers to recognize patterns and evaluate databases.

hyperlinks

CMPD – Center for Materials Processing Data (http://cmpd.asminternational.org/home)
IPB – Innovation Partnership Building at Teck Park, UConn (https://techpark.uconn.edu/)
SME – Manufacturing Day (https://www.sme.org/engage/manufacturing-day/)
ASM – Materials Camp (https://www.asmfoundation.org/students/materials-camps/)

For Students and Teachers Making Curriculum Connections, see the following:

Connecticut State Department of Education (CSDE) - Common Core State Standards (CCSS): Mathematics

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others
- CCSS.Math.Practice.MP5 Use appropriate tools strategically

CSDE - Next Generation Science Standards: Scientific and Engineering Practices

- Asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using Mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information.

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